INDOOR AIR QUALITY ASSESSMENT

Leicester Memorial Elementary School
11 Memorial School Drive
Leicester, MA 01524

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
May, 2005

Background/Introduction

At the request of Mr. Carl Wickland, Facilities Manager of the Leicester School Department, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) conducted an indoor air quality assessment at the Memorial School (MS), Leicester, Massachusetts. This assessment was prompted by concerns of water damage experienced in the library.

This school was originally visited by Cory Holmes, Environmental Analyst of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, on March 10, 1998 (MDPH, 1998). Mr. Holmes conducted a follow-up assessment in November 5, 1999 (MDPH, 2000). This most recent assessment was conducted on June 10, 2004 by Sharon Lee, Environmental Analyst, ER/IAQ Program.

The school is a two story brick building constructed in 1954 and is the former Leicester Junior High School. The school was converted into an elementary school circa 1995. A drop ceiling was later installed in the library. Several rooms in the school were adapted for elementary school functions; for example, the former ground floor shop area is now the library and music room. Classroom 2 is located in the former home economics area. The ground floor contains the cafeteria, computer room, nurse's office, resource room, teachers' lounge, general classrooms, guidance office, main office, several teachers' offices and an office for the school's Drug Awareness and Resistance Education (D.A.R.E.) representative, as well as the aforementioned library and music room. The top floor consists mainly of general classrooms.

Methods

MDPH staff performed visual inspection of building materials for water damage and/or microbial growth. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Actions on Previous Recommendations

As discussed, MDPH staff last visited the building in November 1999. A summary of actions taken on previous recommendations from the report issued in January 2000 is included as Appendix A of this reassessment.

Results

This school houses approximately 420 third to fifth grade students and approximately 50 staff members. The tests were taken during normal operations at the school. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 ppm in 11 of 33 areas surveyed, which is indicative of a poor air exchange in some areas. It is important to note that several areas were empty or sparsely populated and/or had

open windows at the time of assessment. Low room occupancy and open windows can greatly reduce carbon dioxide levels.

Fresh air in classrooms is supplied by unit ventilator (univent) systems (Picture 1). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Some univents were not operating or were operating weakly at the time of the assessment. Obstructions to airflow, such as desks and other items located on or in front of univents, were also observed (Picture 1). To function as designed, univents must be allowed to operate and remain free of obstructions.

Exhaust ventilation is provided by a mechanical system that draws air into ungrated floor level holes in classrooms. Airflow is controlled by a flue located inside the duct. This system appeared to be operating in all classrooms. Some exhaust holes were blocked by items (Picture 3). As with univents, exhaust ventilation must remain free of obstructions to function as designed.

In addition to mechanical ventilation, most rooms at the MS also have ceiling fans (Picture 4). These ceiling fans help to circulate air within the room, especially during warmer months when windows are open. At the time of the assessment, many classroom ceiling fans were operating, especially in rooms where univents were off/operating weakly and windows were open.

It is also worthwhile to not that some rooms had neither windows nor mechanical or passive ventilation for air exchange. A fresh air source is necessary for the dilution of

indoor air pollutants. Without sufficient supply and exhaust ventilation, environmental pollutants can build up, leading to indoor air quality complaints.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat

irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix B.

The temperature measurements ranged from 74° F to 80° F, which were within or slightly above the MDPH recommended comfort guidelines (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, temperature control is often difficult without operating the ventilation systems as designed (e.g., univents/exhaust vents deactivated/obstructed).

The relative humidity in the building was within a ranged from 46 to 60 percent, which is within the MDPH recommended comfort range. The MDPH recommends a comfort range of 40-60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water-damaged ceiling plaster and efflorescence was noted in some areas, especially in the gym area (Picture 5). Efflorescence appears as a white, chalky residue and is a characteristic sign of water damage, but it is not mold growth. As moisture penetrates and works its way through plaster, water-soluble compounds dissolve, creating

a solution. As the solution moves to the surface, the water evaporates, leaving behind white, powdery mineral deposits. A coat of paint can serve as a water impermeable barrier, which can trap moisture. While plaster is not a viable source for mold growth, water trapped in spaces between the paint and plaster can become mold growth media. It appears that a plastic water catching apparatus was also assembled in the gym (Picture 6).

Water-damaged ceiling tiles were noted in the library and other areas of the school. Such damage was noted in both the drop ceiling tile systems (Picture 7) and the older ceiling tiles, which are glued directly to the ceiling throughout the building (Picture 8). Water-damaged ceiling tiles are evidence of historic roof or plumbing leaks. These ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

In some areas of the library, ceiling tiles from the drop system were missing. MDPH staff observed that the original glued ceiling tiles were still intact above the drop ceiling tile system (Picture 9). Missing ceiling tiles can serve as pathways for dust, dirt, odors and other pollutants to move into occupied areas. As previously discussed, water-damaged ceiling tiles can serve as a source for mold growth. Consideration should be given to removing all water-damaged glued ceiling tiles from the library.

As discussed, the purpose of this reassessment was to assess water damage to ceiling materials in the library. According to school personnel, there are active roof leaks causing water damage to materials in this area. MDPH staff observed the roof and noted areas with pooling water (Picture 10). The rubber membrane also appeared degraded and cracked in some areas (Picture 11). Repairing/replacing the roof is necessary to prevent further water penetration.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

Other areas of potential mold growth were observed. Open seams between the sink countertop and wall were observed in several rooms. If sink countertops are not watertight, moisture can penetrate through the seams, causing water damage. For example, a clapboard countertop was noted to be swelling (Picture 12). Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage. As discussed above, moistened materials that are not dried within 24 to 48 hours can become potential sources for mold growth.

Several rooms contained a number of plants (Picture 13). Plant soil and drip pans can provide a source of mold growth. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Plants should also be located away from ventilation sources to prevent the aerosolization of mold, dirt and pollen.

Shrubbery and other plants were growing in close proximity to foundation walls (Picture 14). The growth of roots against the exterior walls can bring moisture in contact

with wall brick. Plant roots can eventually penetrate the brick, leading to cracks and/or fissures in the below ground level foundation. Over time, this process can undermine the integrity of the building envelope, providing a means of water entry into the building through foundation concrete and masonry by capillary action (Lstiburek & Brennan, 2001).

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after

resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detectable (ND) (Table 1). Carbon monoxide levels measured in the school were also ND (Table 1).

As discussed, the US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance

of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particle levels be maintained below 65 μg/m^3 over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

On June 6, 2004, outdoor PM2.5 concentrations were measured at 6 μg/m^3, and PM2.5 levels measured in the school were 5 to 61 μg/m^3 (Table 1). Frequently, indoor air levels of particulates can be at levels higher than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors. During the assessment, PM2.5 levels in the cafeteria were higher than classrooms. These levels can be attributed to cooking/cleaning activities and student activities. Levels above background levels were also noted in classroom 1, where the univent was off; in classroom 3, where students were sweeping and in the gym, where the mechanical exhaust was off.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation

in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no measurable levels of TVOCs were detected, materials containing VOCs were present in the school. In an effort to identify materials that can potentially increase indoor TVOC concentrations, BEHA staff examined classrooms for products containing these respiratory irritants.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

The teachers' aide office contains a lamination machine, wet tone copier (i.e., Risograph®) and photocopier. Lamination machines also off-gas volatile organic chemicals. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992).

Other conditions that can contribute to the indoor air environment includes excessive chalk dust, which was noted in chalk trays of several classrooms (Picture 15).

Chalk can become easily aerosolized and serve as an eye and respiratory irritant. To prevent dust aerosolization, a wet cloth should be used to clean the chalk trays regular.

An inactive insect nest was noted suspended from the ceiling system in one classroom (Picture 16). Nests can contain bacteria and may also be a source of allergenic material. Nests should be placed in resealable bags to prevent aerosolization of allergenic material. These items should also be located away from univents fresh air diffusers. In addition, items should not be suspended from ceiling tile systems. Movement of ceiling tiles may aerosolize dust above ceiling tiles. Moreover, heavy items may damage the ceiling tile frames.

A pet guinea pig was found in one classroom (Picture 17). The cage was lined with wood shavings and had accumulated wastes. Porous materials (i.e., wood shavings) can absorb animal wastes and can be a reservoir for mold and bacterial growth. Animal dander, fur and wastes can all be sources of respiratory irritants. Animal cages should be cleaned regularly to avoid the aerosolization of allergenic materials and/or odors.

Conclusions/Recommendations

In view of the findings at the time of the reassessment, the following recommendations, in addition to those made in the previous report, are made:

1. Operate mechanical supply and exhaust ventilation during occupancy. Inspect exhaust motors and belts periodically for proper function, repair and replace as necessary.

2. Keep univents and exhaust ventilation free and clear of obstructions. Examine flue systems periodically for proper function, repair if necessary.
3. Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation system should be balanced.
4. Continue to replace water-stained ceiling tiles. Examine the area above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
5. Consider removing all water-damaged glued ceiling tiles that are intact above the current drop ceiling system in the library.
6. Keep plants away from univents in classrooms. Examine drip pans periodically for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.
7. Ensure local exhaust ventilation is activated in teachers' aid/music teachers' office whenever equipment is in use to help reduce lamination machine and photocopier odors.
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

9. Consider removing or placing the insect nest into a resealable plastic bag to prevent aerosolization of irritants.

10. Clean and maintain animal cages to prevent bacterial/mold growth and/or odors.

11. Clean chalk boards and chalk trays regularly to avoid the excessive build-up of chalk dust.

12. Consider adopting the US EPA (2000b) document, *Tools for Schools*, in order to provide self assessment and maintain a good indoor air quality environment. The document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

13. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhoFtme.htm.

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Picture 1

Classroom univent

Picture 2

Exterior univent fresh air intake

Picture 3

Blockage to exhaust cubbyhole

Picture 4

Classroom ceiling fan

Picture 5

Water-damaged ceiling plaster

Picture 6

Plastic water catching apparatus

Picture 7

Water damage to ceiling tiles in the drop ceiling tile system

Picture 8

Water damage to ceiling tiles in the glued ceiling tile system

Picture 9

Water-damaged glued ceiling tiles above drop ceiling system in library

Picture 10

Pooling water on roof

Picture 11

Damage to roof membrane, note cracks rubber and efflorescence from building

Picture 12

Picture 13

Plants, note proximity to univent

Picture 14

Plant growth in close proximity to foundation wall

Picture 15

Accumulated chalk dust in tray

Picture 16

Insect nest suspended from ceiling tile system

Picture 17

Guinea pig cage

Memorial School

11 Memorial School Drive, Leicester, MA 01524

Table 1

Indoor Air Results

June 10, 2004

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	ND	64	73	336	ND	ND	6	N # open: 0 # total: 0			Comments: overcast.
cafeteria	150	77	59	1236	ND	ND	30	Y # open: 3 # total: 5	Y univent	Y wall (off)	Hallway DO
Computers	ND	79	53	621	ND	ND	13	Y # open: 0 # total: 3	Y univent	Y ceiling	Window-mounted AC, #MT/AT: 1, PF, Comments: 24 computers.
guidance	1	77	56	1214	ND	ND	18	N # open: 0 # total: 0	N	N	#MT/AT: 1, items.
gymnasium	25	75	60	1007	ND	ND	39	Y # open: 7 # total: 8	Y ceiling	Y wall (off)	Comments: supply likely off.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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									Supply	Exhaust	
Library	24	77	54	611	ND	ND	13	Y # open: 1 # total: 4	Y univent	Y wall (weak)	Plants.
main office	3	77	53	865	ND	ND	12	Y # open: 0 # total: 3	N	N	Hallway DO, plant(s) on carpet, CD, cleaners.
nurse's office	3	76	55	836	ND	ND	16	Y # open: 1 # total: 2	N	N	Hallway DO, Comments: ceiling fan off.
Principal's office	1	75	46	666	ND	ND	15	N # open: 0 # total: 0	N	N	window-mounted AC,
Special Education	4	77	55	759	ND	ND	21	Y # open: 0 # total: 2	N	N	#WD-CT: 10, Comments: wet wiping.

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									Supply	Exhaust	
teachers' aid room	1	75	58	645	ND	ND	16	N # open: 0 # total: 0	N	Y ceiling	PC, laminator, wet toner copier.
1	45	77	63	1585	ND	ND	31	Y # open: 1 # total: 4	Y univent (off)	Y wall	#WD-CT: 15, Comments: WD-sink clapboard.
3	22	75	57	834	ND	ND	61	Y # open: 1 # total: 3	Y univent (off)	Y wall	Hallway DO, CD, DEM, PF, cleaners, Comments: exhaust blocked by bag; Students shuffling and sweeping; ceiling fan off.
4	1	75	57	608	ND	ND	16	Y # open: 2 # total: 3	Y univent (off)	Y wall	Hallway DO, #WD-CT: 25, CD, DEM, PF, plants, Comments: active roof leak reported.
5	20	75	56	709	ND	ND	14	Y # open: 0 # total: 3	Y univent (off)	Y wall	Hallway DO, items, CD, DEM, PF, plants, Comments: butterfly garden kit.

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6	1	75	54	468	ND	ND	23	Y # open: 3 # total: 3	Y univent (off) Blocked by: plant(s)	Y wall	Hallway DO, #WD-CT: 20, CD, DEM, cleaners, plants, Comments: butterfly garden kit.
7	ND	77	53	492	ND	ND	8	Y # open: 2 # total: 3	Y univent	Y wall	FC re-use, items hanging from CT, nests, plants.
8	21	77	60	1043	ND	ND	9	Y # open: 3 # total: 3	Y univent (off)	Y wall	#WD-CT: 17, CD, DEM, food use/storage.
9	ND	74	54	654	ND	ND	7	Y # open: 1 # total: 3			Hallway DO, Inter-room DO, #WD-CT: 2, CD, aqua/terra, Comments: ceiling fan off.

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									Supply	Exhaust	
10	45	77	58	1262	ND	ND	14	Y # open: 1 # total: 3	Y univent Blocked by: plant(s)	Y wall	Hallway DO, #WD-CT: 30, CD, PF, aqua/terra, cleaners.
11	20	76	57	675	ND	ND	10	Y # open: 0 # total: 3	Y univent (off)	Y wall	CD, cleaners, Comments: ceiling fan on.
13	23	77	52	708	ND	ND	6	Y # open: 1 # total: 2	Y univent	Y wall	CD, DEM, pets, Comments: WD-sink clapboard; ceiling fan off.
16	ND	79	80	672	ND	ND	10	Y # open: 3 # total: 3	Y univent	Y wall	Hallway DO, CD, PF, Comments: approximately 21 students left 5 minutes prior to assessment.
17	20	76	54	786	ND	ND	9	Y # open: 3 # total: 3	Y univent (off)	Y	Hallway DO, Inter-room DO, CD, PF, plants, Comments: ceiling fan off.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Memorial School

11 Memorial School Drive, Leicester, MA 01524

Table 1

Indoor Air Results

June 10, 2004

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
18	23	80	49	739	ND	ND	12	Y # open: 2 # total: 3	Y univent	Y wall	Hallway DO, CD, PF, cleaners, food use/storage, plants, Comments: approximately 20 students left 5 minutes before assessment; ceiling fan on; WD-sink clapboard.
19	23	75	52	740	ND	ND	6	Y # open: 3 # total: 3	Y univent	Y wall	Hallway DO, Inter-room DO, CD, items, plants, Comments: ceiling fan on.
20	23	80	50	704	ND	ND	12	Y # open: 3 # total: 3	Y univent Occluded/ blocked by: dust/debris plant(s)	Y wall	Hallway DO, CD, PF, plants, Comments: ceiling fan on.

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									Supply	Exhaust	
21	21	75	56	701	ND	ND	9	Y # open: 2 # total: 3	Y univent (off) Occluded with: dust/debris	Y wall	Hallway DO, Inter-room DO, CD, PF, Comments: ceiling fan on.
22	22	80	51	729	ND	ND	6	Y # open: 3 # total: 3	Y univent	Y wall	Hallway DO, CD, PF, cleaners, Comments: ceiling fan; WD-sink clapboard.
23	ND	74	53	403	ND	ND	6	Y # open: 3 # total: 3	Y univent (off) Occluded with: dust/debris	Y wall	Hallway DO, CD, PF, Comments: ceiling fan on; WD-sink clapboard.
24	25	79	56	923	ND	ND	18	Y # open: 2 # total: 3	Y univent (weak)	Y wall	CD, items, Comments: ceiling fan on.

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
resource 113	1	76	51	806	ND	ND	16	N # open: 0 # total: 0	N	N	DEM, cleaners.
Resource 120	3	76	57	927	ND	ND	24	Y # open: 0 # total: 2	N	N	CD, PF, Comments: cleaning room.

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Appendix A

Actions on Previous Recommendations

MDPH had previously made 13 recommendations to improve indoor air quality at the Memorial School. Many of these recommendations have been acted upon by the Leicester School Department. The following is an update on actions taken in response to MDPH recommendations based on verbal reports from the Leicester School Department and/or direct observation by BEHA personnel during this re-evaluation.

RECOMMENDATION 1: Continue with activities to improve the building's ventilation system. Operate mechanical supply and exhaust ventilation during occupancy. Inspect exhaust motors and belts periodically for proper function, repair and replace as necessary.
ACTION: Univents and filters appeared to be well maintained and most univents were operating at the time of assessment.

RECOMMENDATION 2: Continue to keep univents and exhaust ventilation free and clear of obstructions. Examine flue systems periodically for proper function, repair if necessary.
ACTION: Items were noted in front of some univents and exhausts. All classroom exhaust ventilation was operating at the time of the reassessment.

RECOMMENDATION 3: Continue to replace water-stained ceiling tiles. Examine the area above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

Appendix A

ACTION: Water-damaged glued ceiling tiles and suspended ceiling tiles were observed with water damage. Staff were monitoring roof leaks. Replacement of water-damaged ceiling tiles from the suspended ceiling tile system is reportedly on-going.

RECOMMENDATION 4: Keep plants away from univents in classrooms. Examine drip pans periodically for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.

ACTION: Plants in some classrooms observed on windowsills in close proximity to the univents.

RECOMMENDATION 5: Ensure local exhaust ventilation is activated in teachers' aid/music teachers' office whenever equipment is in use to help reduce lamination machine and photocopier odors.

ACTION: The exhaust was not operating at the time of the assessment.

RECOMMENDATION 6: Clean and maintain aquariums and animal cages to prevent bacterial/mold growth and/or odors.

ACTION: Occupants of classrooms with pets should monitor and maintain aquariums and animal cages according.

RECOMMENDATION 7: Clean chalk boards and chalk trays regularly to avoid the excessive build-up of chalk dust.

ACTION: Several chalk trays were observed with accumulated chalk dust.